Infiltration Test: Exploring the Flow of Water Through Soils

Activity Overview
Students measure water flow into and through soils.

Objectives
Students will:

1. Compare water movement through soil at different test sites and over time
2. Collect data
3. Interpret results to inform decision-making about school ground plantings
4. Increase understanding of water soil dynamics
5. Understand human impact on the landscape

Subjects Covered
Science, Math, and Social Studies

Grades
4 through 12

Activity Time
45 minutes (2 hours wait time)

Season
Spring or Fall

Materials
Option 1: Cut-can Infiltrometer: metal cylinders (approximately 15 cm (six inches) in diameter and 13 to 20 cm (five to eight inches) in length); hammer; scrap wood board (an 18 inch two by four works well); stopwatch, or watch which reads in seconds; and a measuring cup with capacity for one half a liter, or 1 pint.

Option 2: Water Absorption Test: shovel, ruler, stopwatch, 2 - 3 gallons of water

Background

How water flows into and through a soil has great implications for the diversity of plants that can be supported by that soil. Different species of plants will be favored by a slow versus fast draining soil. Accordingly, the choice of plant species for a native planting or ecological restoration is determined in a large part by the dynamics of soil and water. Water flow through soil also plays a significant role in how large to build a rain garden.

There are a number of factors which can influence how wet or dry a particular soil is and how water infiltrates the soil. The physical structure and texture of the topsoil is a key characteristic affecting water flow. A sandy soil has larger pore spaces than a clay soil. Pore spaces are the air spaces between particles. This allows water to percolate or infiltrate the soil more quickly. Clay soil is made up of smaller particles and pore spaces slowing water's ability to infiltrate.

Subsoil characteristics can also play a major role in water movement. A heavy (clay) subsoil layer can act as a seal underneath the topsoil. If there is enough rain, the topsoil will become saturated and there will be no place for the water to go regardless of the characteristics of the topsoil.

Soil compaction can lead to destruction of soil structure (the arrangement of soil particles and pore spaces), and thus reduce water flow. The pore spaces and natural cracks are squeezed out in a compacted soil creating a cement-like soil. Heavy construction vehicles, poor farming practices and even walking on wet soil destroys soil structure and impedes water flow.

The amount of water being held by a soil at the time of testing can also greatly affect how water soaks into the ground. A saturated soil will usually have a different flow rate than the same soil in an unsaturated state. This is due to the presence of soil-water matrix forces in unsaturated conditions. These matrix forces are complex and result from a combination of adhesion forces (the attraction between soil surfaces and water) and cohesion forces (the attraction of molecules of water to each other). In saturated conditions gravitational forces alone are responsible for water movement in soils.

The first infiltration test described below is used to quantify the ability of water to move into and through a soil. Because of the great number of factors which can affect the flow of water through soils, it is best to use this test on a relative basis. This means that a number of tests could either be run at the same time at different sites or at the same site at different times. The results from that particular set of tests are then only directly compared to each other. This technique is suitable to long-term soil infiltration testing. Usually as native plants mature and their roots spread, infiltration changes. This procedure can be used to track change over time.

State Standards
Science:

Use scientific sources & resources (B.4.1)

Select multiple information sources (C.4.3)

Use data to answer questions (C.4.5)

Identify data and sources to answer questions (C.8.2)

Evaluate data (C.12.3)

Choose & evaluate data collection methods (C.12.4)

Math:

Use reasoning abilities (A.4.1, A.8.1, A.12.1)

Work with algebraic expressions (F.8.1)

Model & solve mathematical & real-world problems using algebra (F.12.4)

The second infiltration test is often used to learn soil type for determining how big to build a rain garden. The rate at which the water soaks into the ground indicates if the soil is sandy, silty, or like clay. Soil is a critical factor for calculating the size of a rain garden. See Earth Partnership for Schools activity "Sizing a Rain Garden" for more information and/or to take the next step in planning a rain garden. Learning soil type will also inform plant selection for any planting. Matching plants to soil type will help in choosing plants that will survive your proposed planting.

Activity Description

Option 1: Cut-Can Infiltrometer (Best for follow-up infiltration tests.)

Winnequah Middle School students performing water flow testing, Madison, WI. Photo: Cheryl Bauer-Armstrong

Carefully choose and prepare a test site. A level location will give the best results by allowing the water to infiltrate evenly into the soil. A site with gravel will most likely be difficult or impossible because of difficulties in sinking the cylinder into the soil. A heavy lawn sod will create similar difficulties because of the dense mat of roots. Work around living plants, and expose bare soil by removing any leaf litter. Disturb the soil surface as little as possible.

Sink the cylinder into the soil approximately five to seven centimeters (two to three inches) to create a tight seal between the bottom of the cylinder and the soil. You will most likely need to use a hammer to do so. It is best to place a wood board on top of the cylinder when hammering to keep from denting its top. Hammer in circles around the top to keep the cylinder perpendicular with the soil surface. During the test, if water leaks out the bottoms and sides of the cylinder, your results will be skewed. You will need to repeat the test with the cylinder either further in the soil or sunk more carefully so the soil is less disturbed along the cutting edge of the cylinder.

Have your watch ready and add the water to the cylinder. Time how long it takes for all of the water to move into the soil with complete elimination of all puddles.

Additional considerations

Some soils have very slow infiltration rates, and this can lead to unnecessarily long run times. If you suspect you might have this problem you can use an alternative procedure which is a bit more complicated, but also more efficient. Graduate your cylinder by making one centimeter (or one half inch) marks up its inside. To calibrate your gradations measure how deep a given amount of water will fill an uncut can and extrapolate to your scale.

As an interesting related math activity, this same measurement can be achieved by calculating the volume corresponding to your gradations. Measure the diameter of your cylinder and calculate its cross-sectional area. (Remember the area of a circle = πr^2.) Multiply this number by the length of your gradation to determine the corresponding volume. Your calculations will be greatly simplified if you use metric units (one cubic centimeter = one milliliter).

Option 2: Water Absorption Test (Best for rain garden planning.)

Perform the following infiltration test at each location selected for a potential rain garden.

1. Dig a hole 6 inches deep by 6 inches in diameter.
2. Fill hole with water and let stand for one hour.
3. Refill hole with water. Measure depth of water with a ruler.
4. Let stand 1 hour. Then measure the depth again.
5. Use the following chart to determine soil types based on the rate at which water soaks into the soils.

Soil type	Sand	Silt	Clay
Rate	2.5 inches/hour or 4 hours total	1/2 inches/hour or 12 hours total	1/3 inches/hour or 18 hours total

1. Record soil characterization data on field sheets.
2. Use data collected in Earth Partnership for Schools activities, “Designing a Rain Garden” and “Sizing a Rain Garden.”

Extensions

- Test the difference in water flow through saturated versus unsaturated soils. Does the rate of infiltration vary with different soils?
- Investigate infiltration through subsoil. Carefully dig off the topsoil, and place the infiltrometer into the subsoil layer.
- Compare infiltration rates between compacted soil and uncompacted soil. Observe and identify visual characteristics of compacted soil on the school grounds.
- Research what you can do to improve soil infiltration.

Additional Resources

- If interested, purchase a double ring infiltrometer for infiltration testing. They are available from Turf -Tec International at 1.800.258.7477 or http://www.turf-tec.com/index.html

Web sites

- Globe in the City - Infiltration: www.centerx.gseis.ucla.edu/globe/protocols/infilt.htm

Assessments

- Using the results of the infiltration tests, describe how different soil types and/or soil compaction influences water flow through soil.
- Based on the results of the infiltration tests, where would you locate a rain garden for best infiltration?
- Describe the factors that influence soil permeability.

Infiltration Field Test Data Sheet

Date: ____

Soil type	Sand	Silt	Clay
Rate	2.5 inches/hour or 4 hours total	1/2 inches/hour or 12 hours total	1/3 inches/hour or 18 hours total

Water Absorption Test Data Sheet - 1

Vegetation Type

Lawn, garden, field, other ______________________

Soil Characteristics

Tilth -- compacted, intermediate, fluffy, other ______________________
Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist ____________

Infiltration Rate __________ inches/hour

Soil Type __________________________

Water Absorption Test Data Sheet - 2

Vegetation Type

Lawn, garden, field, other ______________________

Soil Characteristics

Tilth -- compacted, intermediate, fluffy, other ______________________
Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist ____________

Infiltration Rate __________ inches/hour

Soil Type __________________________

Water Absorption Test Data Sheet - 3

Vegetation Type

Lawn, garden, field, other ______________________

Soil Characteristics

Tilth -- compacted, intermediate, fluffy, other ______________________
Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist ____________

Infiltration Rate __________ inches/hour

Soil Type __________________________

Infiltration Field Test Data Sheet

Cut-Can Infiltrometer Data Sheet - 1

Vegetation Type

Prairie, woodland, savanna, garden, other ______________________

Soil Characteristics

Texture -- sand, loam, clay, other ______________________
Tilth -- compacted, intermediate, fluffy, other ______________________
Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist _____________

Infiltration Rate

__________minutes/500 ml

(Note: If a different volume was measured, give the rate as minutes per 500mls)

Cut-Can Infiltrometer Data Sheet - 2

Vegetation Type

Prairie, woodland, savanna, garden, other ______________________

Soil Characteristics

Texture -- sand, loam, clay, other ______________________
Tilth -- compacted, intermediate, fluffy, other ______________________
Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist ____________

Infiltration Rate

__________minutes/500 ml

(Note: If a different volume was measured, give the rate as minutes per 500mls)

Cut-Can Infiltrometer Data Sheet - 3

Vegetation Type

Prairie, woodland, savanna, garden, other ______________________

Soil Characteristics

Texture -- sand, loam, clay, other ______________________
Tilth -- compacted, intermediate, fluffy, other ______________________
Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist ____________

Infiltration Rate

__________minutes/500 ml

(Note: If a different volume was measured, give the rate as minutes per 500mls)